- Atmospheric Infrared Sounder (AIRS)
- Advanced Microwave Sounding Unit (AMSU)
- Humidity Sounder from Brazil (HSB)

- Aqua Spacecraft

Improving Weather and Climate Prediction

AIRS Project Overview

NASA Sounder Science Team Meeting
Greenbelt, MD

November 3, 2010

T. Pagano
California Institute of Technology, JPL

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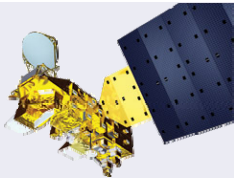
The Atmospheric Infrared Sounder on NASA's EOS Aqua Spacecraft



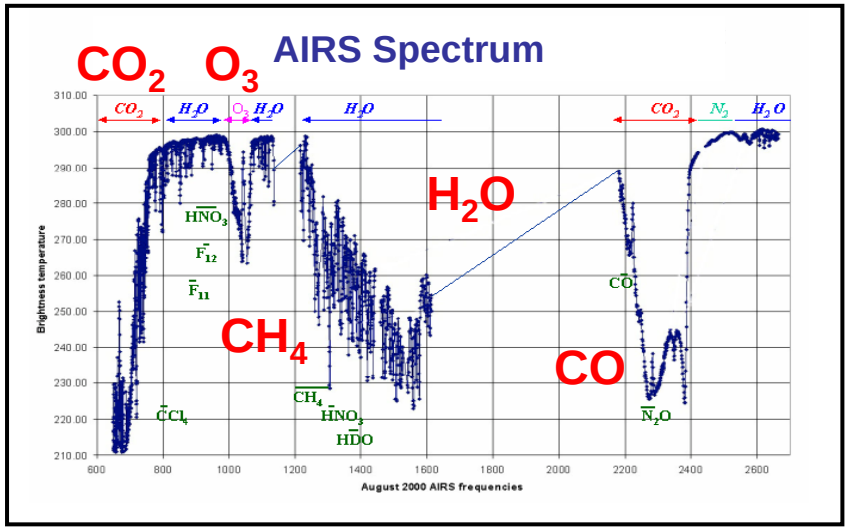
AIRS Characteristics

- Launched: May 4, 2002, Aqua S/C
- Orbit: 705 km, 1:30pm, Sun Synch
- IFOV : 1.1° x 0.6° (13.5 km x 7.4 km)
- Scan Range: ±49.5°
- Solid State Grating Spectrometer
  - IR Spectral Range: 3.74-4.61 μm, 6.2-8.22 μm, 8.8-15.4 μm, $(\lambda/\Delta\lambda) \approx 1200$

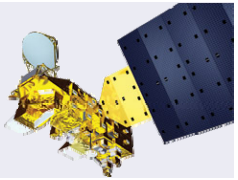
Science Objectives

- Improve Weather Forecasting
  - AIRS Data Assimilated into Operational Forecasts at NWP Centers Worldwide
- Improve Climate Prediction
  - AIRS Provides Unprecedented 3D view of water vapor, temperature and clouds
- Observe Greenhouse Gases
  - First Global Maps of Mid-Trop CO2

AIRS



Operations Status



- AIRS
  - In excellent health. No significant trends in engineering parameters
- AMSU-A
  - In good health. No worrisome trends in engineering parameters
  - 12 of the 15 channels are performing well with no issues at all
    - Channel 5, while still useful, is degrading steadily and will probably become too noisy to use sometime late this year or early next year
    - Channel 4 was declared non-operational in 2007
    - Channel 7 has been noisy since launch and has never been used
  - AMSU-A2 temperature read out anomaly that occurred on 11/16/2004 suddenly disappeared (read outs returned to normal) on 06/21/10
    - There is a small impact on calibration that will necessitate a minor software update
  - AMSU's built with 5 year life. Other AMSU's degrading more than ours
- Aqua
  - Spacecraft is in very good condition
  - The most conservative estimate says fuel will last until 2017—it could well last a few years beyond

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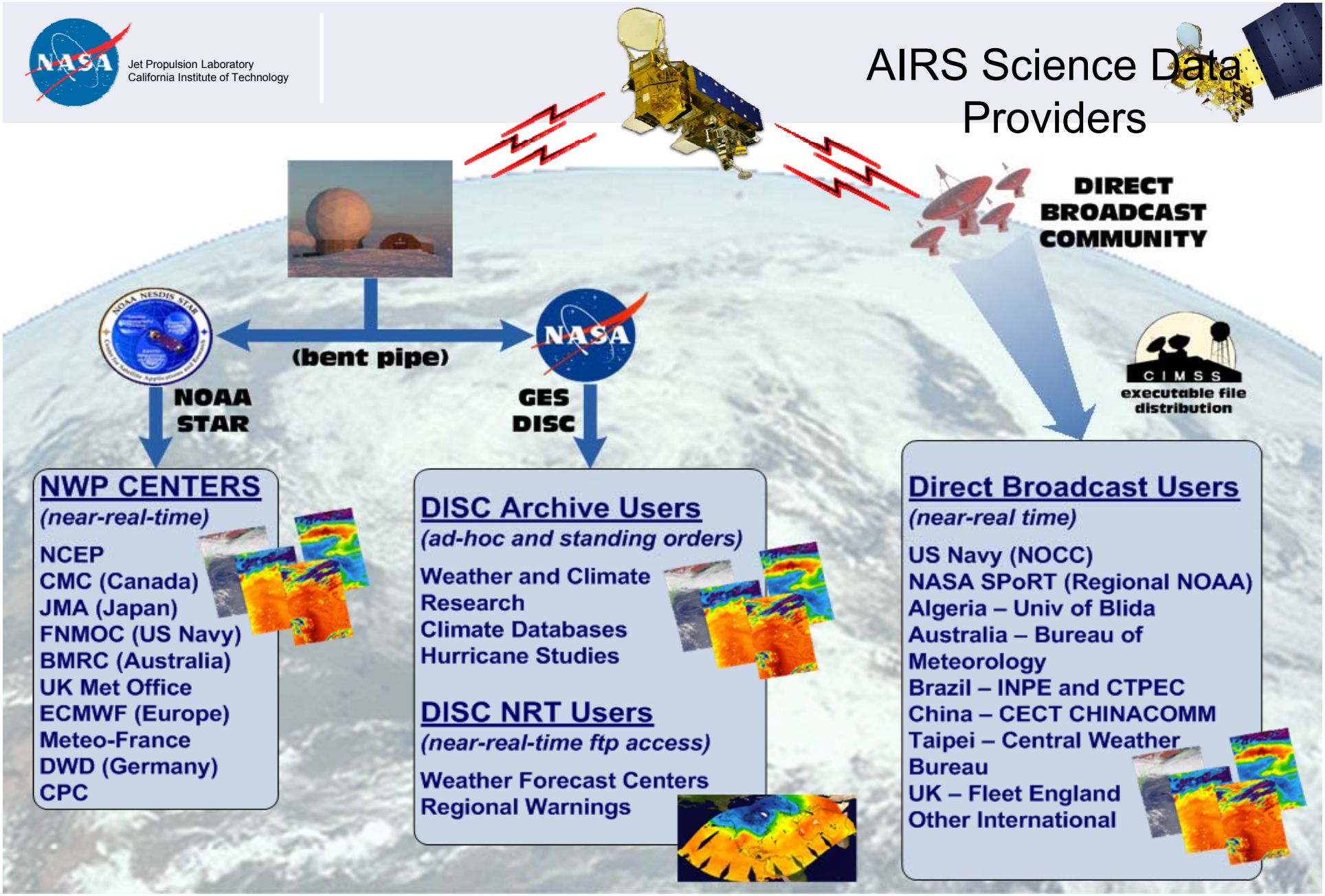
AIRS Science Data Providers



http://airs.jpl.nasa.gov

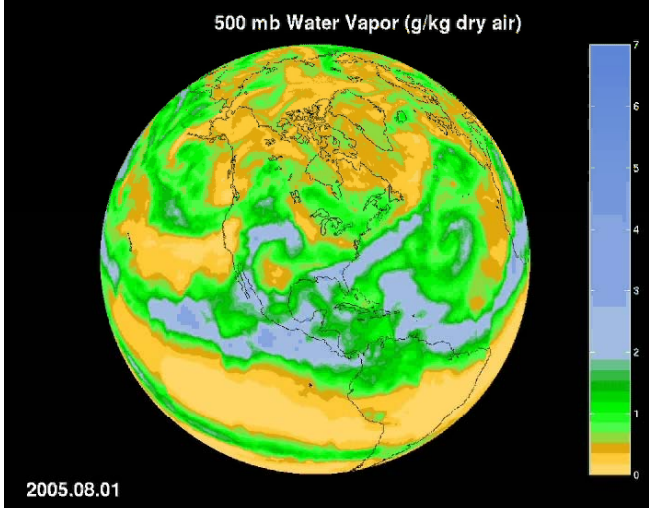
http://disc.sci.gsfc.nasa.gov/

National Aeronautics and
Space Administration

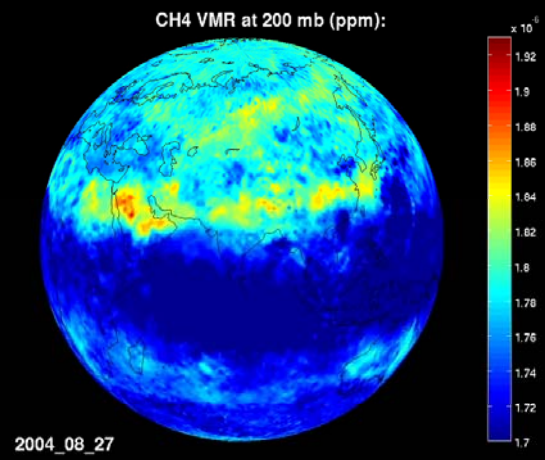
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

AIRS Greenhouse Gases

H_2O

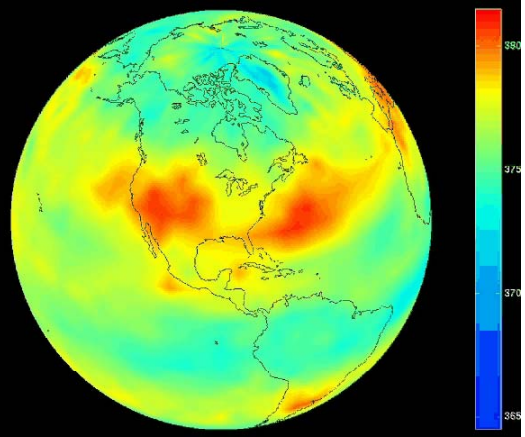


CH_4



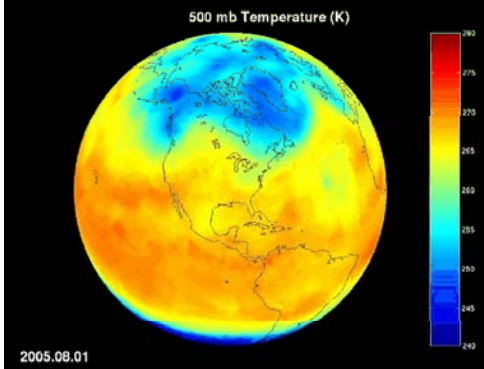
CO_2

Mid-Tropospheric CO_2 (ppm)

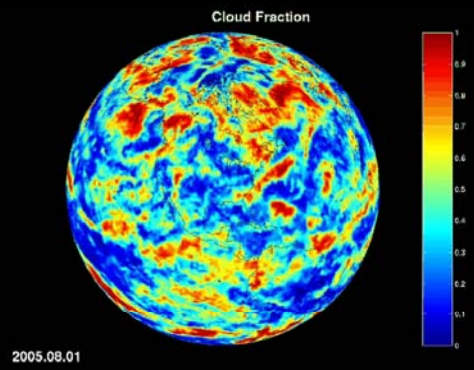


Pagano, JPL, 2009

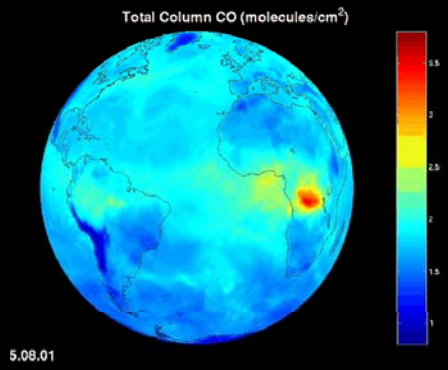
Other AIRS Atmospheric Climate Products



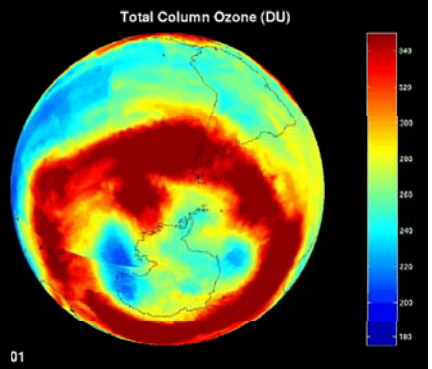
Temperature



Clouds



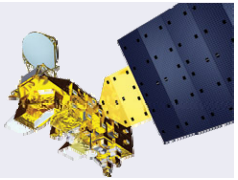
CO



O_3

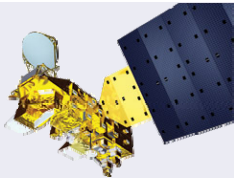
Pagano (JPL)

AIRS e-Library



- ~ 140 GB of PDF files menu-linked for easy access
- BAE & JPL Design File Memos ~ 6000
- AIRS CAD drawing files (8 different file formats)
  ~ 5500 drawings including sub–contractors & vendors
- Linked 22 page tree for easy access to drawings
- AIRS Project Document Library (subject menu linked to searchable documents)
- AIRS Instrument Anomaly Fault Flow linked by subsystem to flow charts, displays, procedures and design documentation for rapid, on-orbit anomaly resolution

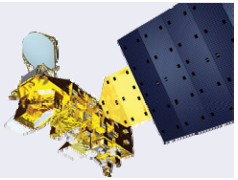
Calibration Status



- For Version 6, Level 1B is unchanged
- Level 1C includes the following changes important for climate applications
  - small improvements to radiometric calibration
  - cleanup of spectra to eliminate very noisy channels
  - small spectral gaps between detector modules filled in
  - spectral frequency shift determination and correction
    - Earth-rotation and spacecraft motion Doppler shift correction (New Requirement)
    - Orbital
    - Seasonal
    - Long-term non-periodic—new model required (recent data do not fit old model)
- Three versions of Level 1C code are required
  - a version to run at the GES DISC in their environment (a new PGE which uses the PGE toolkit)
  - a standalone version that does not require the toolkit
  - a version for integration into the Level 2 PGE
- Algorithm development and coding are complete, except for the revised long-term component model

D. Elliott (JPL)

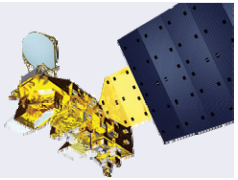
Version 6 Software Development



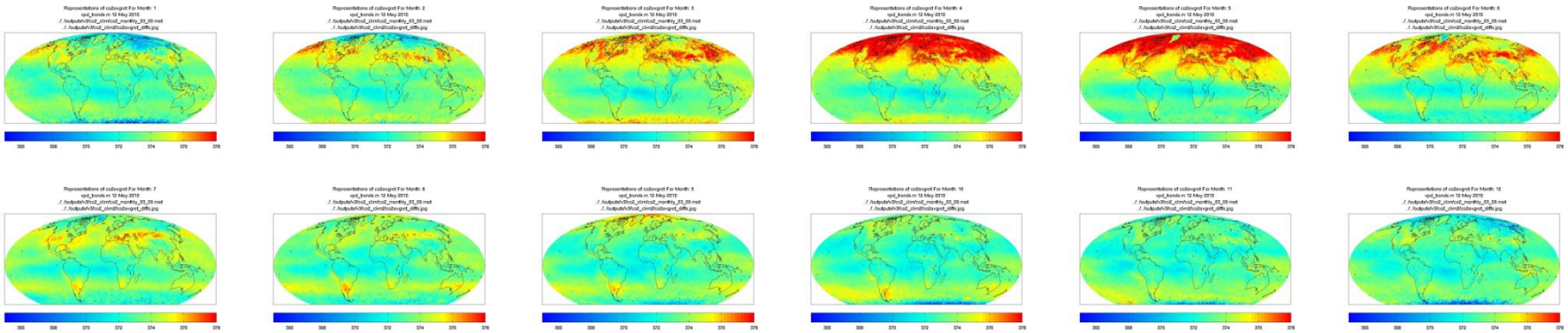
- Level 2 PGE: Final V6 features (defined at AIRS Science Team Meeting during April 2010) have been incorporated into the code baseline:
  - NOAA – updated regression coefficients, incorporated and tested RTA code (the latter from UMBC)
  - UMBC – delivered Stochastic Cloud Clearing, Neural Network (SCCNN) initial guess, delivered updated RTA coefficients (to NOAA).
  - GSFC – integrated L2 retrieval components from NOAA components, finished revision of Quality Control and error parameterization, and finalized end-to-end full-retrieval code
  - JPL – integrated final L2 PGE components identified above into an “evaluation candidate” and began verification and testing
  - Additional Science Team inputs which occur in the L2 production stream after the full-retrieval are being coded and tested for integration by JPL into the L2 code baseline in early 2011. (These features have no impact on the full-retrieval component of L2.
- The last remaining algorithmic issues pertaining to L1C code have now been finalized. An updated version of L1C will be produced.
- Level 3 development, which has been put on hold during L2 development, will be completed during Level 2 testing period.

S. Friedman (JPL)

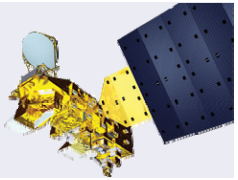
AIRS CO2 Product Development Status



- Version 5 CO2 Product Available for Entire Mission at GES/DISC
- Level 2 and 3 Formats Available.
- Data will be available in 3 layers
  - Mid-Trop. Now Available. Validation in final stages
  - Statospheric Product Algorithm Complete. Ready for Operational Code Development and Validation
  - Lower-Tropospheric Algorithm Under Development
- AIRS 12 Month Mid-Tropospheric CO2 “Climatology” Developed Expect release by end of calendar year.



User Services Request and Registered Users Growing



- User Services
  - As of October 22, 2010
    436 questions have been asked and answered at AskAIRS
  - 12 submitted in 2010
  - 106 submitted in 2009
  - 74 submitted in 2008
  - 68 submitted in 2007
  - 43 submitted in 2006
  - 56 submitted in 2005
  - 53 submitted in 2004

- Registered Users
  - As of October 22, 2010
    there are 711 Registered AIRS Data Users

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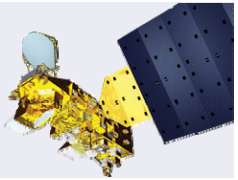
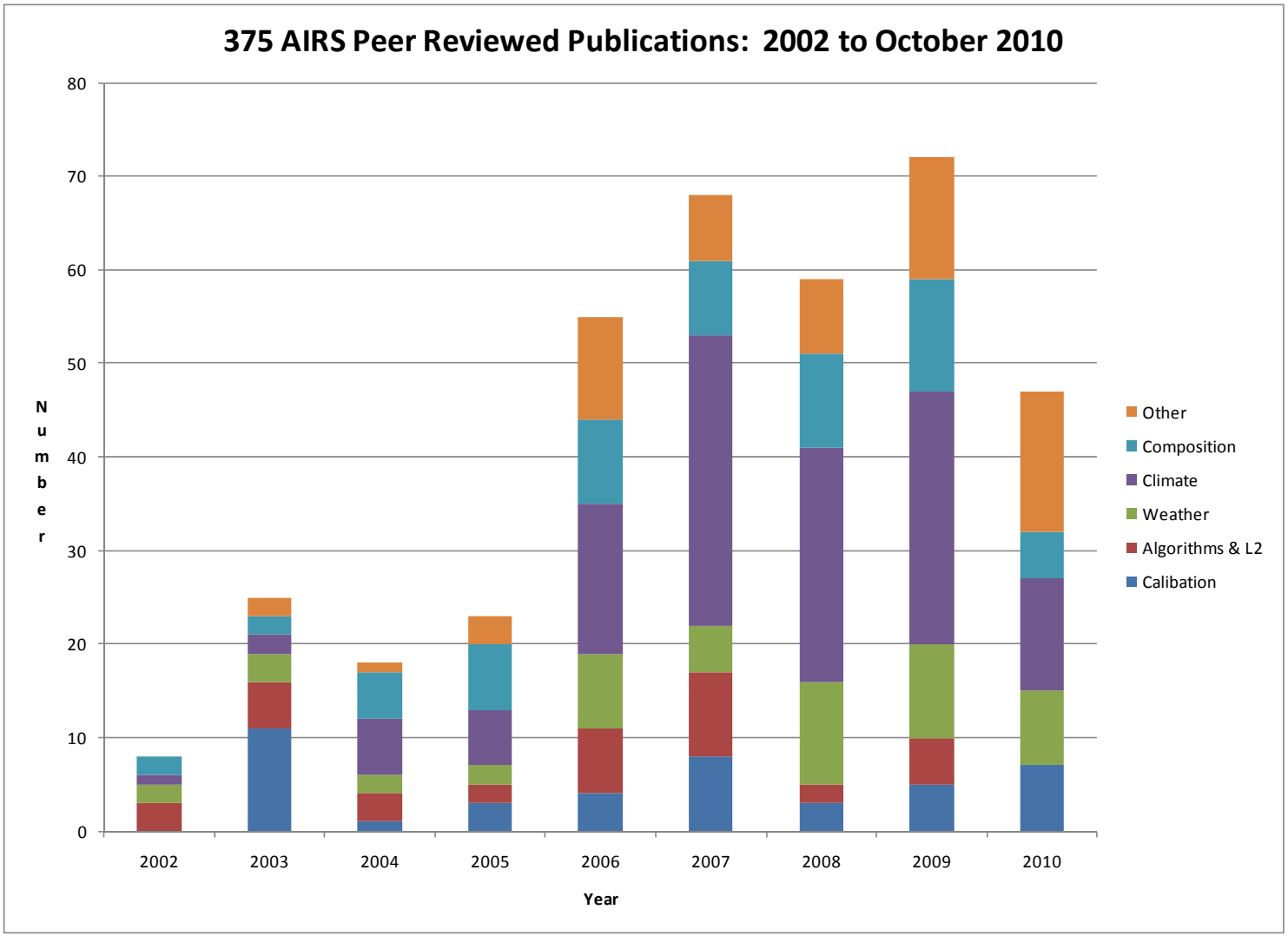
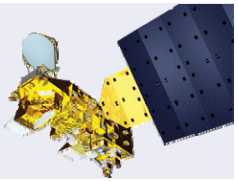
375 AIRS Peer Reviewed Publications to Date





ECMWF Finds High Infrared Sounder Impact



- Microwave satellite measurements (AMSU-A) are responsible for 18% of the forecast error reduction
- Infrared measurements (AIRS and IASI) for 12% each
- 10% of error reduction is due to radio occultation

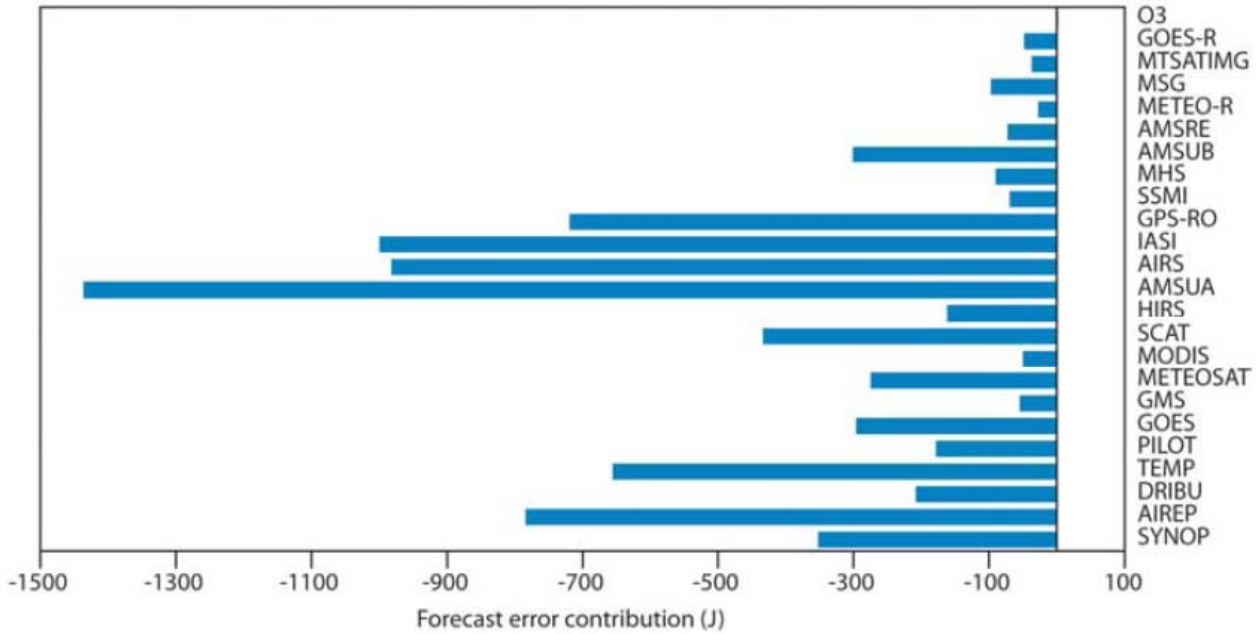
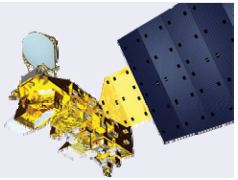


Figure 11. 24-hour forecast error contribution (Joule10^{-4}) of the components (types) of the observing system during September, October, November and December 2008. Negative (positive) values correspond to a decrease (increase) in the energy norm of forecast error.*

From Cardinali (ECMWF Tech. Memo. 599, 2009)

See also, Cardinali, C, Monitoring the observation impact on the short-range forecast, Q. J. R. Meteorol. Soc. 135: 239–250 (2009)

What is the value of AIRS?



- Lars Peter Riishojgaard (JCSDA) at the A-Train Symposium
  - 20% of our economy is weather sensitive ($3B/year)
  - “Weather is not just an environmental issue; it is a major economic factor. At least $1 trillion of our economy is weather-sensitive.” (former commerce secretary William Daley)
  - Potential Savings due to Forecast $75B/Year
  - Most forecasts for 14 days implies $200M/hour improvement
  - US Falling behind in forecast skill
  - Per Sensor Contribution of AIRS and IASI is “Astonishing”
- How does AIRS save considering Lars’ assumptions
  - AIRS has 5 hrs improvement on 6 day forecast
  - AIRS Saves over $1B/year!
- AIRS Costs: $200M
  - “The forecast improvement accomplishment alone makes the AIRS project well worth the American taxpayers’ investment”, Dr. Mary Cleave, former Associate Administrator for NASA's Science Mission Directorate

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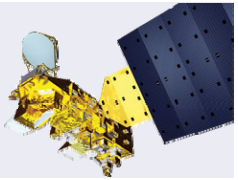
Summary and Conclusions



- Aqua Spacecraft and AIRS/AMSU Instruments in Good Health
- Forecast improvement from AIRS amongst the highest for any single instrument
- Science discovery still very high
  - Over 375 peer reviewed publications to date
- New operational uses
  - Carbon Monoxide and Volcanic emissions monitoring
- Version 6 development continues
  - Improvements to Instrument Calibration: New Level 1C
  - Improvements to product yield and accuracy in lower troposphere
  - Reduction of bias trend in temperature and water vapor
  - Expect completion in mid 2011
- New products on the horizon
  - Stratospheric and Lower Tropospheric CO2
  - Cloud Microphysical Properties
- Workshop Complete. Expect report draft before end of calendar year.

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